(12) UK Patent Application (19) GB (11) 2 233 365 (13) A

(43) Date of A publication 09.01.1991

(21) Application No 9012736.6

(22) Date of filing 07.06.1990

(30) Priority data
(31) 8914443 (32) 23.06.1989 (33) GB

(51) INT CL[5]
E21B 33/068

(52) UK CL (Edition K)
E1F FJS

(56) Documents cited
GB 0689829 A US 4821799 A US 4476924 A

(58) Field of search
UK CL (Edition K) E1F FJS
INT CL[5] E21B

(71) Applicant
Otis Engineering Corporation

(Incorporated in the USA – Delaware)

P O Box 819052, Dallas, Texas 75381-9052, United States of America

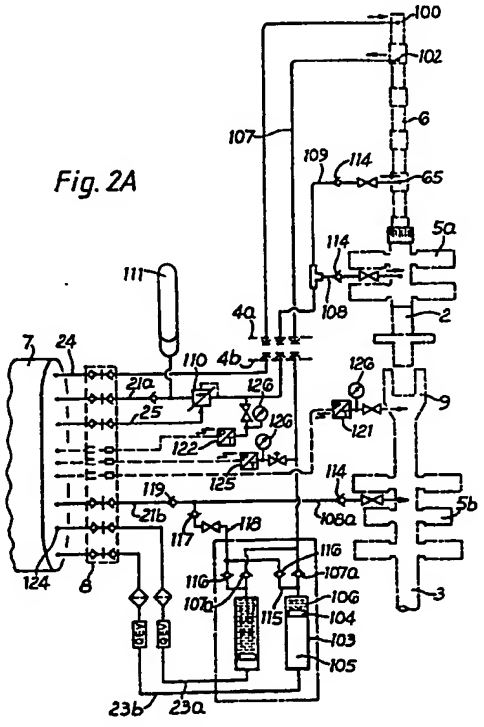
(72) Inventors
Peter Cowan
Thomas Robb

(74) Agent and/or Address for Service
Mewburn Ellis
2 Cursitor Street, London, EC4A 1BQ, United Kingdom

(54) Sub-sea wireline grease control system

(57) A sub-sea wireline unit is provided with a remotely operable grease injection and control system. Grease is supplied at high pressure to an upper wireline valve (5a) in a lubricator assembly (2, 3) and to an injection port (65) in a grease control head (6) secured to the assembly. At the top of the control head there is a wiper and a grease outlet port (102) is immediately below the wiper. The grease outlet port communicates with a pair of reservoirs (103) that operate in alternation, one collecting the grease received from the control head and the other turning collected grease under pressure to a lower wireline valve (5b) on the lower part (3) of the lubricator assembly. It is thus possible to maintain a continuous grease pressure in the wireline passage to seal the line and also to collect continuously grease returned from the grease outlet port.

Fig. 2A



GB 2 233 365 A

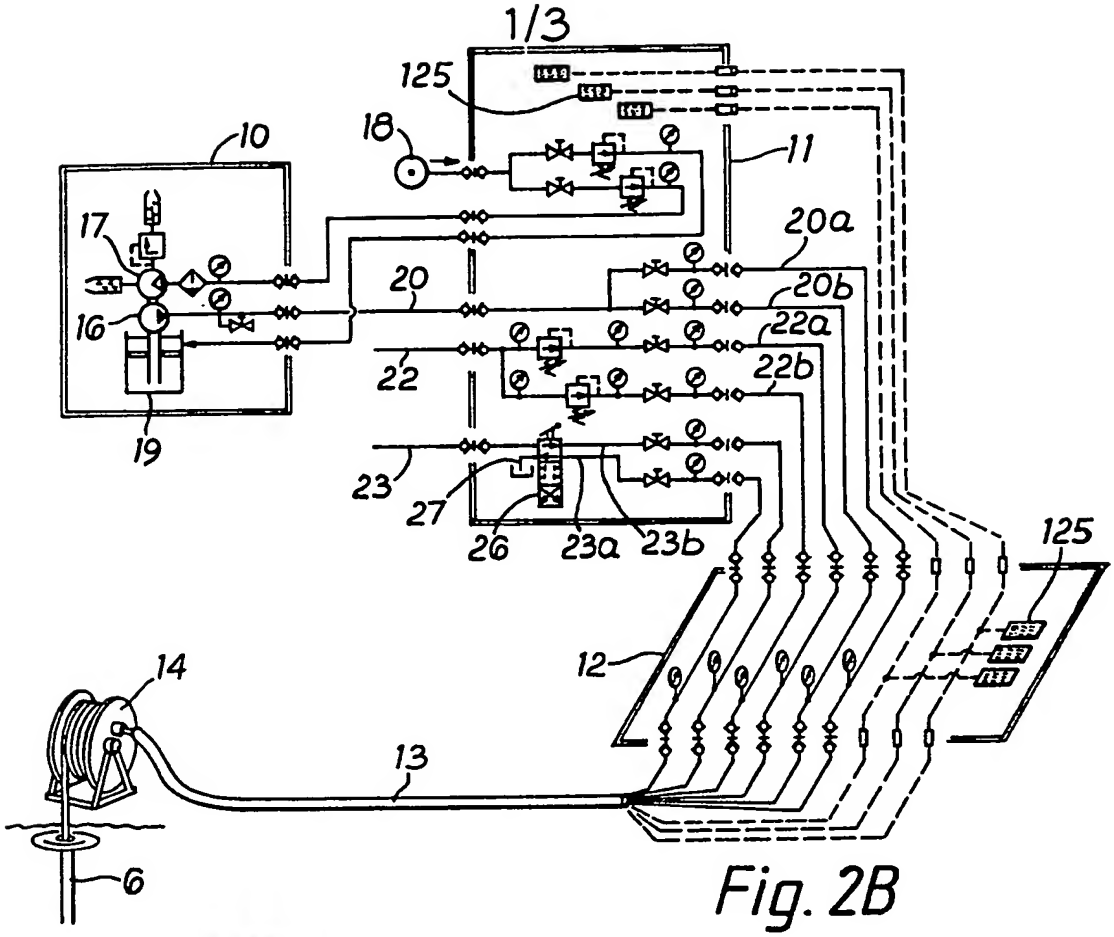

125
18
10
11
17
20a
20
20b
16
22a
22
22b
19
23
27
26
23a
23b
125
12
14
13
6

Fig. 2B

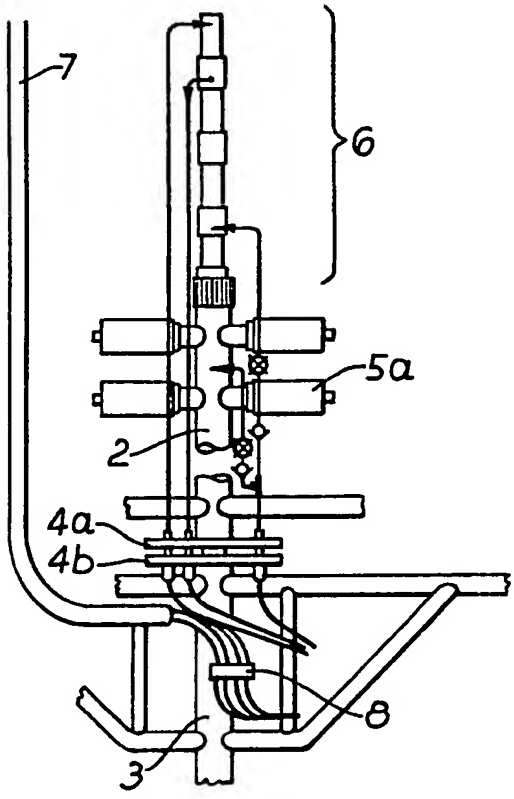
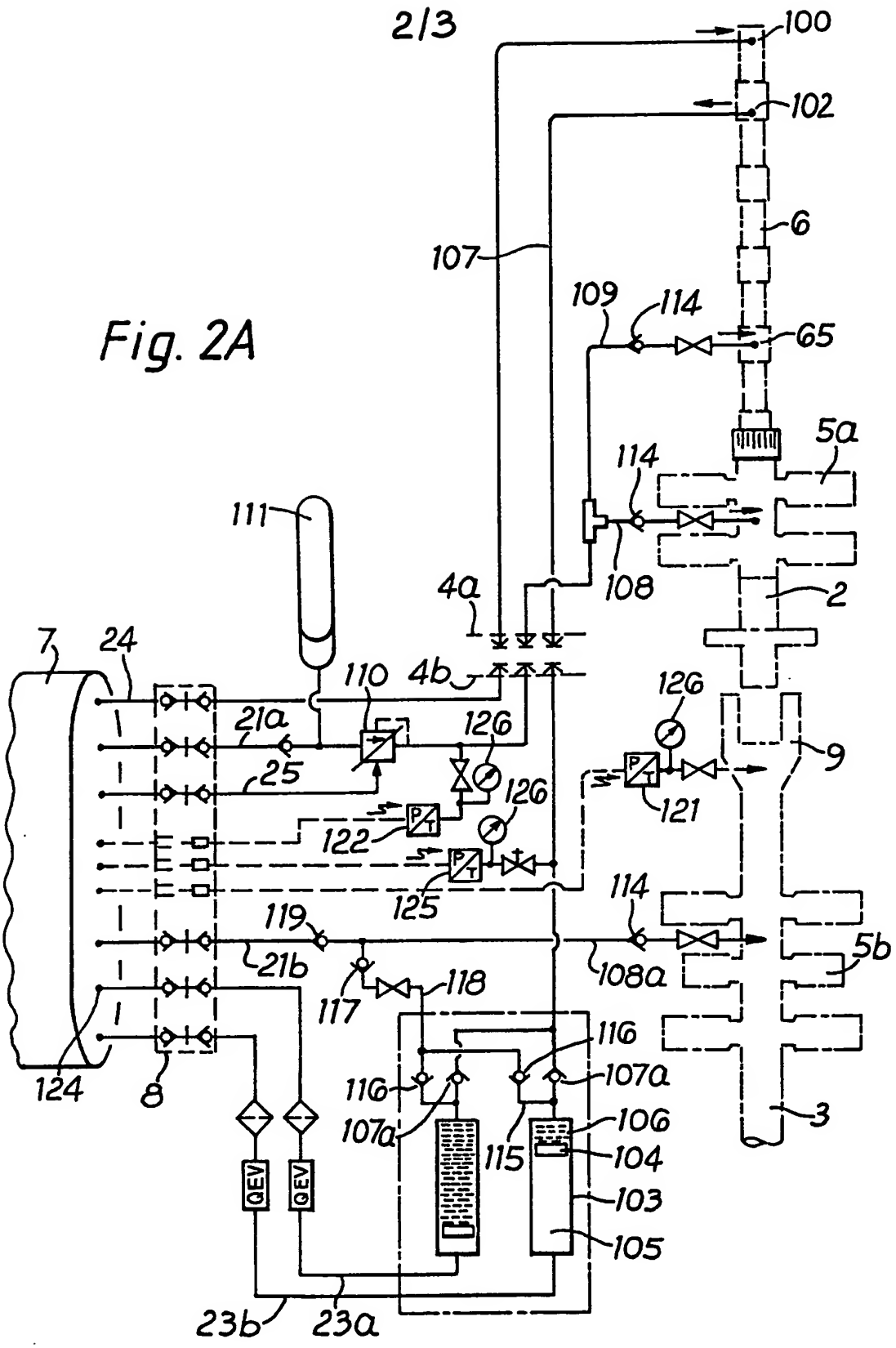

7
6
5a
2
4a
4b
8
3

Fig. 1

Fig. 2A


100
102
6
107
109
114
65
5a
114
111
108
4a
2
7
24
110
4b
126
21a
126
9
25
126
121
122
125
114
119
5b
21b
108a
117
118
116
116
107a
107a
106
115
104
103
105
3
124
8
QEV
QEV
23b
23a

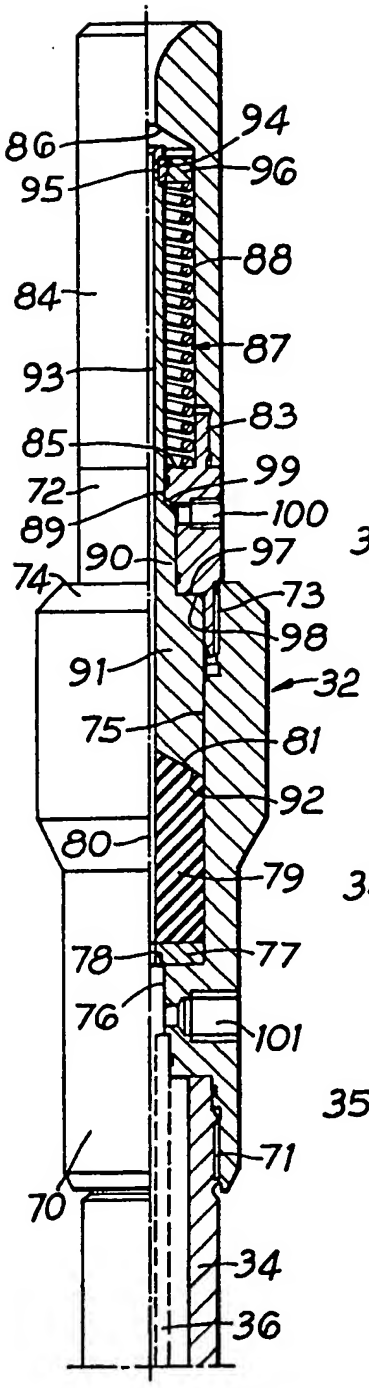


Fig. 3A

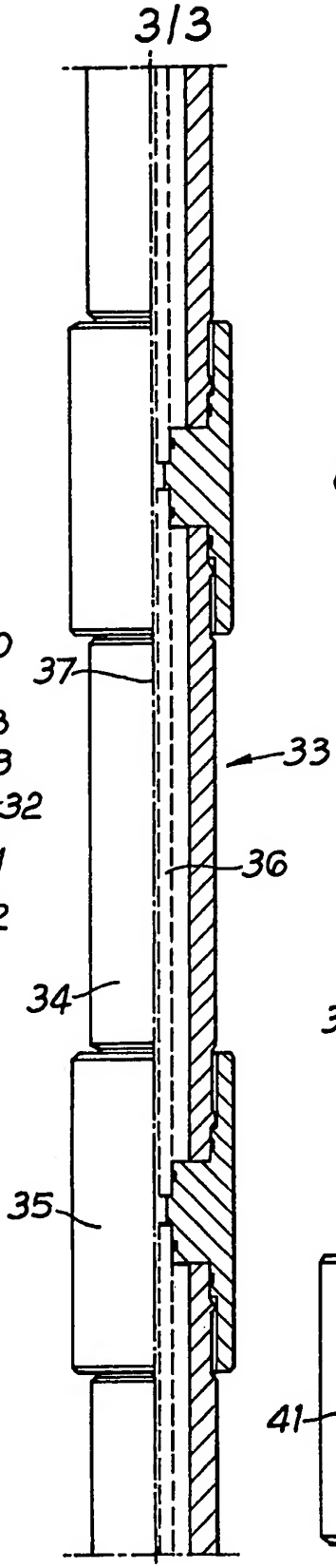


Fig. 3B

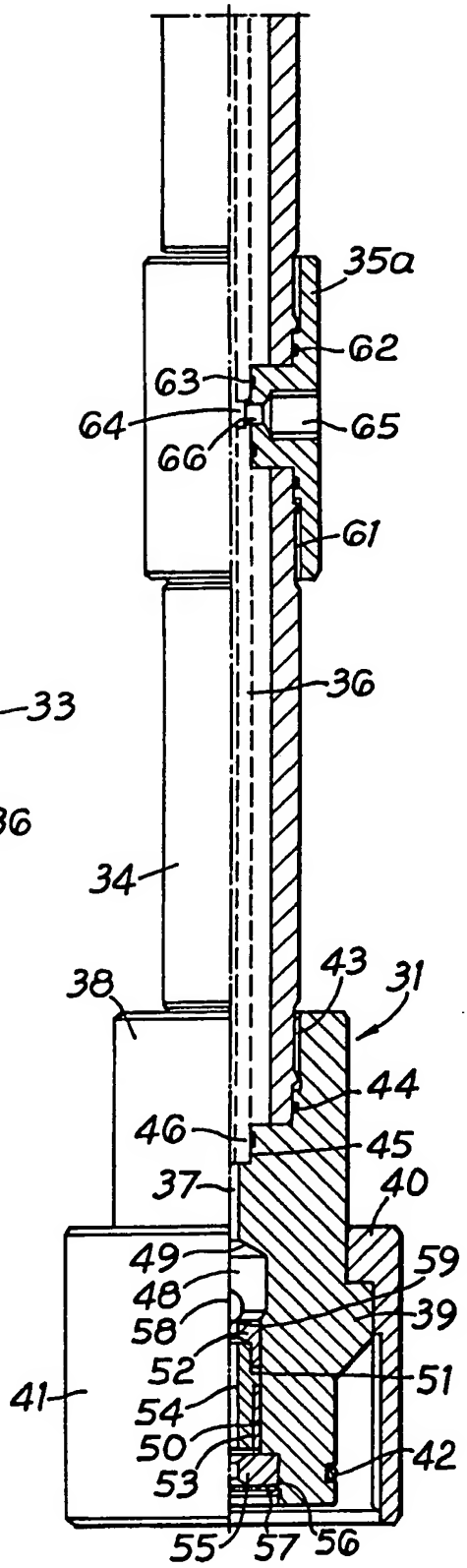


Fig. 3C

SUB-SEA WIRELINE GREASE CONTROL SYSTEMS

This invention relates to grease control systems for the containment of well fluids in sub-sea wireline operations.

When performing service operations in a well using a flexible braided wireline, it is known to employ a grease control head having a tubular passage through which the wireline runs with a very small clearance and to pump grease or like sealing fluid into the control head to form a viscous seal in that small clearance space. The seal prevents pressure fluids escaping from the well by flowing along the wireline.

It is to be understood that in many of its aspects the present invention is primarily concerned with grease control systems for handling braided wirelines, which give rise to greater problems than slickness. In US 3209830 a grease control head is provided at the upper exit for a slickline, the control head comprising a stuffing box which, in conventional manner, consists of a series of packing discs compressed axially against each other to be urged radially inwards and bear sealingly on the line. Such stuffing boxes are suitable only for use with slicklines, because they cannot seal between the individual wires of a braided cable. However, while the present invention is primarily concerned with sealing

methods that can be employed for braided wirelines, although these will generally be applicable also to slicklines.

In grease control heads such as are shown in US 4476924 installed at the well head, it is also known to provide a container for collecting surplus fluid from the grease control head. With these earlier arrangements the difficulty then arises that, if operation of the grease control head is not to be interrupted, it is necessary to have access to replace the container, the switch-over being completed manually. In sub-sea operations this is only possible if the surplus fluid is collected at the surface.

US 4821799 proposes a method for injecting grease continuously at a constant pressure during wireline operations, pumping the grease into an accumulator in its path to the grease control head. Pressure is supplied to the accumulator by a pressurised gas source, which may be aided by spring means, to inject grease from the accumulator to the control head. This system provides better control of injection pressure but the surplus grease is again collected in a containment that must be periodically cleared.

Known control systems, including those described above are customarily mounted at the surface, even when employed on a sub-sea well. It is also known, however, to dispose a grease control head on a sub-sea well head, with grease supply and return lines running between the control head and the surface. Such an arrangement brings a number

of additional problems. If the well is at some depth, the time taken to pump the grease from the surface can make it impossible to maintain a stable pressure in the control head. Furthermore, there is an increased risk of leakage from the control head and contamination of the surrounding waters because of the high back pressure in the return line where the grease is being lifted against a considerable head.

In these known systems, whether the control head is mounted sub-sea or on the surface, there is a risk of hydro-carbons reaching the surface rig along the wireline passage and/or the grease return line, and elaborate precautions are mandatory for dealing with such a contingency. It would therefore be desirable to maintain all fluid passages through which well fluids may escape remote from any surface control point from which the sealing system is operated.

In a main aspect the present invention is particularly concerned with sub-sea grease control heads that with means for collecting surplus grease from a wireline so as to reduce contamination of the surroundings.

For optimum results, it would be desirable, moreoever, to provide a means by which grease wiped from a wireline in a grease control head can be continuously collected and removed so that the wiping process can be continued without interrupting the use of the wireline.

According to one aspect of the present invention,

there is provided apparatus for sealing around a flexible wireline extending into a well head, comprising:

(a) a lubricator assembly for mounting on the well head and having a through passage for the wireline,

(b) grease injection means on said lubricator assembly for injecting grease under pressure into said passage to seal around the wireline,

(c) grease outlet means on the lubricator assembly leading from said through passage at a location remote from the grease injection means and the well head,

(d) supply conduit means and return conduit means connected respectively to said grease injection means and said grease outlet means,

(e) a plurality of reservoirs having respective inlet means from said grease return conduit means, and respective return means to said grease supply conduit means,

(f) fluid pressure means for acting selectively on the reservoirs to expel grease accumulated in a respective reservoir to said grease supply conduit means,

whereby to provide reservoir capacity for a flow of grease from said outlet means while maintaining a continuous grease supply pressure in said injection means.

The invention will be described in more detail with reference to the accompanying drawings. In the

drawings:

Fig. 1 is an outline illustration of the sub-sea unit of a grease control system according to the present invention, mounted on a sub-sea well head,

Fig. 2A is a schematic illustration of part of the unit in Fig. 1, illustrating the hydraulic and electrical connections on the sub-sea unit to an umbilical that extends from the surface,

Fig. 2B is a similar schematic illustration showing the connections to the umbilical on the surface rig servicing the well head, and

Figs. 3A, 3B and 3C give a more detailed illustration of the grease control head in the apparatus of Fig. 1 to a larger scale.

The sub-sea unit illustrated in Fig. 1 is mounted on an underwater well head or Christmas tree (not shown) through a comprising upper and lower lubricator assemblies or stacks 2,3 of generally conventional construction, and a grease control head 6. The lower lubricator assembly 3 is secured to the well head. The upper lubricator assembly 2 part is connected to the lower assembly part by respective connection plates 4a,4b on the respective assemblies adjacent to their junction. The attachment plate 4a on the upper asembly 2 mates with the attachment plate 4b when the upper assembly 2 is secured releasably on the lower assembly 3 by means of a remotely operated latch 9.

The detachable upper lubricator assembly 2 serves in known manner to retrieve a wireline tool (not shown)

after it has been used for servicing apparatus in the well head and to replace it with a further tool if required. Within the assemblies 2,3 an axial passage (not shown) is provided for the wireline (not shown) on which the tool is suspended. The upper lubricator assembly comprises a dual wireline valve 5a and the lower assembly comprises a triple wireline valve 5b. These valves are of generally conventional construction and will not be described in detail here as they are not directly relevant to the present invention. The grease control head 6, through which the wireline also passes, normally remains secured to the upper assembly 2.

Hydraulic and electrical lines for operating and monitoring the sub-sea unit are brought from the surface in an umbilical cable 7 and connected to the sub-sea unit through an attachment plate 8 on the permanently fixed lower lubricator assembly 3 mounted on the underwater well head. Self sealing couplings of conventional form on the attachment plate provide connections from the umbilical to a series of conduits and electrical conductors that run to the hydraulic connection plate 4b at the top of the lower assembly 3 part or direct into the lower assembly, as will be described below in more detail. The two connection plates 4a,4b have plug-in hydraulic connectors of conventional form at their junction for the fluid lines. The line connections are thus made between the upper and lower lubricator assemblies simply by locating the upper assembly 2 on the lower assembly 3 and can be broken in

manner by lifting the upper assembly from the lower assembly.

Fig. 2B shows the surface portion of the grease control system for the well wireline operations, which may be mounted either on a platform or aboard ship. This portion comprises a grease pump unit 10, a wireline unit 11 and a central control van 12. Indicated by conventional symbols in these units, but not otherwise identified, are releasable fluid couplings, shut-off valves, pressure regulators, pressure gauges, mufflers, and an air filter. From the control van 12 there runs a deck umbilical 13 containing power and signal lines as well as grease pumping lines. The deck umbilical is connected in known manner to the sub-sea umbilical 6 mounted on a reel 14 from which the sub-sea umbilical can be paid out.

More specifically, in the grease pump unit 10, there is a pump 16 for high-pressure fluid of the required viscosity (referred to herein as "grease") to lubricate and seal the wireline over the sub-sea well head for servicing operations, and a compressed air drive 17 for the pump powered from the rig pressure air supply 18. Depending upon the type of pump employed, the unit may also have an accumulator 19 to which the rig pressure air can be supplied through a line to maintain pressure in the lubricant on pump output line 20 to the wireline unit 11 that constitutes the supply and control means for the underwater portion of the grease control system.

The pressure line from the grease pump 16 is

branched in the wireline unit 11 to provide two outlets 20a,20b each with a shut-off valve and pressure gauge, for upper and lower grease lines 21a,21b respectively in the sub-sea portion of the grease control system. The wireline unit 11 also receives from the surface rig a first hydraulic supply 22 at medium pressure (1500 psi) and a second hydraulic supply 23 at high pressure (6000 psi). The medium pressure line 22 is branched in the wireline unit into two lines 22a,22b to supply, respectively, a line wiper control conduit 24 and pilot control conduit 25 in the sub-sea unit as will be described in more detail below, each of these control branches having its own shut-off valve. The wireline unit 11 also has a shuttle valve 26 in the high pressure supply line 23 to connect that high pressure supply to either of two alternative output lines 23a,23b and the other of said two output lines to a return line 27. The shuttle valve 26 also has an intermediate position in which it is closed to all flow through it.

The central control van 12 provides a monitoring station in which the pressure in the grease and hydraulic lines 20a,20b,22a,22b,23a,23b to the umbilical are indicated and there are also digital read-outs, duplicated in the wireline unit for pressure measurements taken in the sub-sea unit.

The grease control head 6 is illustrated in more detail in Figs. 3A, 3B and 3C. It comprises lower and upper sections 31,32 secured together through an intermediate section 33 formed by an alternating series of

coupling sleeves 34 and connectors 35 enclosing a series of flow tubes 36, the sections being in coaxial relation and providing a passage 37 for the wireline extending with a small clearance through the flow tubes.

The lower section 31 of the grease control head provides a blow-out preventer should the wireline be severed and pulled out of the head. The section comprises a tubular main body 38 having an integral collar 39 which is engaged by a circular flange 40 of a threaded cap 41 by means of which the control head is connected to the hydraulic stack upper part 2 with sealing provided by a captive sealing ring 42. At its upper end, the body 38 has a threaded outer counter-bore 43 in which a first coupling sleeve 34 is screwed and is engaged by a sealing ring 44 below the counter-bore thread. Below said sealing ring 44 the body 38 has a smaller inner counter-bore 45 in which a first flow tube 36 is a sliding fit and is engaged by a further sealing ring 46 that seals between the body and the flow tube.

Below the flow tube the wireline passage 37 in the body 38 opens at its lower end into a valve chamber 48 having a frusto-conical top seating face 49 adjoining the passage 37. Below the chamber 48 a smaller bore 50 holds a slidable tubular plunger 51 comprising upper and lower casing portions 52,53 secured to a resilient inner sleeve 54. The plunger is held captive by an abutment ring 55 in lower counter-bore 56, the ring 55 being secured by a spring clip 57. A valve ball 58 is contained in the

chamber 48. When a wireline is inserted the ball is pushed to one side of the chamber away from the wireline passage. In the absence of the wireline the ball is free to move under prevailing pressure conditions, being driven either upwards by well pressure to seal against the frusto-conical face 49 and prevent the escape of well fluids, or downwards by water pressure from outside to seal against top conical face 59 of the plunger 51 to prevent leakage of water into the well head. In particular, leakage of well fluids can be prevented if the wireline should fracture and be blown out of the grease control head.

In the intermediate section 33 of the grease control head, at the upper end of the first coupling sleeve 36 and flow tube there is a first tubular connector 35a in the form of an injection nipple. The first coupling sleeve has a threaded engagement 61 with the connector 35a and the connector carries sealing rings 62,63 for sealing with the coupling sleeve and the flow tube respectively. A second coupling sleeve 34 and flow tube 36 extend downwards into the upper end of the first connector 35a and are similarly engaged there by a screw-thread 61 and by sealing rings 62,63.

Between the first and second flow tubes 36 a central region of the connector 35a has a bore 64 of smaller diameter bore than the outside diameter of the flow tube and a threaded inlet 65 in the connector communicates with the space between the flow tubes through a transverse bore opening 66 into the central region bore 64 to provide

a grease injection port communicating with the interiors of the adjoining flow tubes.

The second flow tube and coupling sleeve are secured at their upper end to a second tubular connector 35 of the same construction the connector 35a except that it has no grease injection tapping. Further flow tubes and coupling sleeves alternate with further tubular connectors, all being of identical form to the tubes, sleeves and connectors already described. Secured to the topmost coupling sleeve and flow tube and forming the upper part 32 of the grease control head is a line wiper comprising a tubular lower body part 70 having a threaded connection 71 with the top coupling sleeve 34 and a tubular upper body part 72 having a threaded collar 73 engaging an internally threaded collar 74 of the lower body part. The internal diameter of the collar 73 is the same as that of main bore 75 of the lower body part. Sealing rings 75,76 are provided between the body lower part and the top coupling sleeve and flow tube, and there are further sealing rings 77 between the two body parts.

The bore 75 extends through the lower body part to a smaller diameter end bore 76 opening into the top flow tube. A rigid bearing ring 77 rests on shoulder 78 at the bottom of the bore and supports the lower end face of a resilient sealing device 79 comprising a pair of rubber elements of semi-circular cross-section that together form a tubular sealing body with a narrow central bore 80 and a conical top face 81.

The upper body part 72 has a lowermost bore 82 of substantially the same diameter as the bore 80. At its upper end the upper body part terminates in a threaded collar 83 to which an exit wire guide 84 is secured. Between opposed shoulders 85,86 on the bores of the upper body part and the wire guide an annular pocket 87 is formed to contain a biasing spring 88. Below the pocket the upper body part has a first smaller diameter bore 89 and a second bore 90 having a diameter between said first bore and the lower body part main bore 75.

A piston 91 fits slidably within the bores 89,90,75 of the upper and lower body parts. Sealing rings on the two bores 89,90 of the upper body part engage corresponding diameter portions on the piston. The larger diameter end of the piston sliding in the main bore 75 has a conical face 92 complementary to the opposed face of the sealing body. The piston extends above the upper body part with thin-walled tubular portion 93 to above the top of the spring 88. A recess 94 is formed in the outer wall of the tubular portion 93 to receive a diametrically split collet 95 that has a downwardly tapered outer face engaging with a complementary tapered inner face of a support ring 96. The support ring 96 is urged into engagement with the collet 95 by the spring 88 which is compressed between it and the shoulder 85 on the body upper part. The spring thus urges the piston upwards to the end position illustrated in which respective shoulders 97,98 on the body upper part and the piston are in abutment. In this position there is a small

annular chamber 99 formed by the projection of the piston tubular portion 93 into the body upper part bore 90.

The annular chamber 99 is in direct communication with the medium pressure supply line 24 which leads to a tapping 100 in the upper body part opening into the chamber. By applying hydraulic pressure to the chamber 99, the piston 91 is driven downwards against the force of the spring 88 and the tubular sealing device 79, thereby deforming the walls of the bore 80 inwards. A wireline extending through the grease control head which can pass freely through the bore 90 when the piston is in its top end position is embraced by the sealing device 79 as it deforms inwards. As the wireline is drawn upwards, grease is thus stripped from it by the pressure of the sealing device to prevent such grease being carried into the surrounding water. A grease outlet 102 is located immediately below the sealing device 79, opening into the bore 76 of the lower body part. As the wireline is raised, therefore, surplus grease can be removed through the outlet, as will be described below.

The lower lubricator assembly 3 has mounted on it a pair of hydraulic accumulators 103 in the form of vertical-axis cylinders each with a piston 104 dividing the interior into a lower hydraulic fluid space 105 and an upper grease space 106. The two high pressure hydraulic lines 23a,23b are connected to the respective lower spaces 105. The upper spaces 106 are each connected to the lower grease supply line 21b from the umbilical, the line 21b

105. The upper spaces 106 are each connected to the lower grease supply line 21b from the umbilical, the line 21b continuing via line 108a to the triple wireline valve 5b. These upper spaces 106 are also connected via non-return valves 107a to line 107 from the grease outlet 102.

Grease supplied from the surface through the upper supply line 21a can flow through branches 108,109 to the dual wireline valve 5a and the grease injection port 65 in the control head 6. This flow is controlled from the surface by the medium pressure control fluid through the line 25 to a pilot control regulator 110 on the lower stack part. Upstream of the regulator 110, the grease supply line 21a is connected to a buffer accumulator 111. Should there been an interruption, during wireline operations, in the flow of grease from the surface, the accumulator 111 provides a reserve supply to the wireline passage. Under normal conditions grease will not be supplied under pressure from the surface through the lower line 21b, as will appear below.

Non-return valves 114 prevent return flow from each of the three grease injection points, ie. at the wireline valves and at the injection nipple. In a grease outlet line 115 from each accumulator cylinder 103 there is a non-return valve 116 permitting flow through the line only from the cylinder to the pressure injection line 21b. Another non-return valve 117 operates similarly in the common line 118 that joins the separate lines 115 from the cylinders 103. In the grease injection line 21b there is a

further non-return valve 119 upstream of the connection to the cylinders to prevent return flow.

In the use of the grease control system, the hydraulic stack lower part 3 is put in place at the commencement of operations and the sub-sea umbilical 7 can be connected at any time before or after then to the attachment plate 8. The lower part 3, and if required the umbilical also, remain in place throughout multiple wireline runs in which successive tools suspended on the wireline are brought to the well head using the detachable hydraulic stack upper part 2 to carry them from the surface, the grease control head 6 remaining attached to the upper part.

While tools are being run in the well on a wireline, high pressure hydraulic fluid is supplied to the upper end of one of the cylinders 103, depending on whether the valve 26 is switched to select the line 23a or the line 23b as the high-pressure line. The other of the cylinders has its hydraulic fluid space connected to the return line 27 and thus provides a low pressure path and receptacle for grease wiped from the wireline. As that second cylinder fills with grease, the hydraulic high pressure may be switched to it by the valve 26. The grease accumulated in the second cylinder is then returned to the wireline passage via the triple wireline valve 5b, while surplus grease wiped from the wireline continues to be returned and collected, now in the other of the two cylinders 103. Grease can thus be wiped and returned from the control head

essentially continuously and without interrupting the manipulation of the wireline. Because there is a separate supply to the dual wireline valve 5a and the injection port 65, the pressure supply to the triple wireline valve 5b can be maintained, and can be supplied with grease from the cylinders 103, while the upper lubricator assembly 2 is detached from the lower lubricator assembly 3 and the connectors on the connection plates 4a,4b have been released.

By mounting the cylinders 103 vertically and admitting the returned grease to their upper spaces 106, the pressure in the return line 107 to the cylinders is reduced and can be kept to only slightly more than the ambient water pressure because the weight of the pistons 104 acts to draw grease through the return line. There is an increased efficiency of wiping counteracting the tendency of the grease to escape into the surrounding water through the top of the control head.

Furthermore, effective sealing can be maintained with a continuous high pressure grease supply to the grease injection points below the wiper section, and in particular by virtue of the high hydraulic pressure of the supply line 23 driving grease collected in the cylinders 103 into the triple wireline valve 5b. The apparatus is thus particularly effective in reducing pollution both by minimising the amount of grease that will be carried by the wireline into the surrounding well and by preventing the escape of hydro-carbons from the well head during wireline

operations.

Should the wireline break within the well head or lubricator assembly, there is a risk that the portion left in the grease control head will be blow out by well pressure. The ball valve, as already described, is able to seal off the wireline passage should that happen, and it can also seal the wellhead if the ambient water pressure is greater. The triple wireline valve provide a further seal when the wireline is present, the two upper gate-type closures being extended around the wireline and grease being injected under pressure into the space between them. It will be noted that, in the event of pressure failure in the surface supply line 23a, a grease supply will be available from one or both reservoirs to make the seal at the triple wireline valve.

Despite the presence of these sealing means, it may be necessary to assume that conditions can arise in which some escape of well hydro-carbons occurs through the wireline passage. In an installation in which the grease control head or the grease return line from the control head is at the surface, it would be required to make provision for reducing the dangers of this hazard, which entails considerable complication and additional costs. These are obviated in the present installation since any discharge of hydro-carbons will take place in the immediate vicinity of the well head, remote from any surface rig or vessel controlling the wireline.

To monitor the operation of the grease control

system, pressure transducers are located at sensing stations in the sub-sea grease lines close to the lubricator assembly where the readings will not be falsified by the lengthy lags that can occur at the surface, remote from the wellhead. Illustrated are a transducer 121 for the pressure in the wireline passage in the lubricator assemblies, a transducer 122 for the pressure in the supply line 109 to the control head injection port 65, and a transducer 123 for the pressure in the grease outlet line 107. The cable connections 124 from the transducers extend to the surface through the connector 8 and the umbilical . On the surface, read-outs 125 of the transducer signals are provided in the wireline unit 11 and the control van 12. Each of the transducers on the lubricator assembly is backed up locally by a Bourdon pressure gauge 126, remotely operated camera means (not shown) being employed if it is required to read the gauges.

Some of the salient features of the grease control system that has been described can be summarised in the following:

(i) it is a sealing system that is fully effective on a braided wireline;

(ii) it provides for emergency sealing of the wellhead in the event of the wireline being severed and blown out of its passage or of the grease seal in

the control head being lost, for whatever reason;

(iii) it isolates the escape of well hydro-carbons from the remote control position so as to avoid the risk of a build-up of hazardous fluids near personnel and equipment;

(iv) it permits a continuous supply of grease over an indefinite period of time;

(v) it provides for remote pressure control in conjunction with local metering of pressure and, by locating a pressure accumulator close to the grease control head, pressure lags due to the elasticity of long supply lines can be avoided;

(vi) it allows the grease supply pressure to be controlled and maintained to a desired value within a wide range;

(vii) it allows grease expelled from the wireline passage to be collected continuously and re-circulated, and in particular does not require a dump containment to be cleared from time to time;

(viii) it minimises contamination of the surroundings due to the escape of grease by drawing of the surplus grease at a pressure close to the local ambient pressure to improve the efficiency of cleaning the wireline strands;

(ix) it provides a capability for diverless installation and operation.

CLAIMS

1. Apparatus for sealing around a flexible wireline extending into a well head, comprising a lubricator assembly for mounting on the well head and having a through passage for the wireline, grease injection means on said lubricator assembly for injecting grease under pressure into said passage to seal around the wireline, grease outlet means on the lubricator assembly leading from said through passage at a location remote from the grease injection means and the well head, supply conduit means and return conduit means connected respectively to said grease injection means and said grease outlet means, a plurality of reservoirs having respective inlet means from said grease return conduit means and respective return means to said grease supply conduit means, and fluid pressure means for acting selectively on the reservoirs to expel grease accumulated in a respective reservoir to said grease supply conduit means, whereby to provide reservoir capacity for a flow of grease from said outlet means while maintaining a continuous grease supply pressure in said injection means.

2. Apparatus according to claim 1 wherein wiper means are provided adjacent to and above said grease outlet means.

3. Apparatus according to claim 1 or claim 2 wherein umbilical connecting means extend from the surface to the lubricator assembly, said connecting means comprising said

at least one grease high-pressure supply line and fluid pressure supply lines for said application of fluid pressure to the respective said reservoirs.

4. Apparatus according to claim 3 wherein said umbilical connecting means extends and is secured to a lower part of said lubricator assembly, and detachable coupling means are provided for coupling said at least one high-pressure supply line to an upper part of said assembly which carries a grease control head.

5. Apparatus according to claim 3 or claim 4 wherein it comprises at least one sub-sea grease pressure sensing station and said umbilical connecting means comprises signal lines for transmitting to the surface electrical signals indicating the grease pressure at said least at one sub-sea station.

6. Apparatus according to claim 5 wherein said at least one pressure sensing station is located in said high-pressure injection line between said connecting means and the lubricator assembly.

7. Apparatus according to claim 5 or claim 6 wherein said at least one pressure sensing station is located in the return conduit means between the grease control head and said reservoirs.

8. Apparatus according to any one of claims 4 to 7 wherein said lubricator assembly comprises respective wireline valves in each of said upper and lower parts, and between said two parts there are releasable connection means comprising self-sealing coupling means for coupling said high-pressure injection line to the upper part wireline valve.

9. Apparatus according to claim 8 wherein a further grease injection line extends to the wireline passage in the lubricator assembly lower part.

10. Apparatus according to any one of the preceding claims wherein said grease reservoirs are in the form of hollow cylinders having central axes oriented vertically upon the hydraulic stack, the grease inlet and outlet means of each said reservoir connecting with the top of the reservoir interior.

11. Apparatus according to claim 10 wherein said reservoirs each comprise a sliding piston seal in the reservoir interior between an upper grease space and a lower fluid pressure space.

12. Apparatus according to any one of the preceding claims wherein there are pressure accumulator means on the lubricator assembly and in communication with said high-

pressure injection line.

13. Apparatus according to claim 12 wherein remotely operable pressure regulating means are disposed in said high-pressure injection line downstream of the accumulator means.

14. A grease sealing system for a wireline to a sub-sea well head, comprising

(a) a lubricator assembly to be mounted on the well head, and having a passage through which the wireline passes to the wellhead,

(b) at least one grease high-pressure injection line to the passage in said assembly,

(c) respective wireline valves in said assembly having grease inlet porting to which said at least one grease injection line is connected,

(d) a grease control head sealingly connected to the top of said assembly and having a through passage coaxial with said wireline passage and communicating directly therewith,

(e) a grease outlet in said control head and return conduit means leading from said outlet,

(f) a plurality of grease reservoirs having respective inlet means connected to said return conduit means,

(g) each of said inlet means having a non-return valve for blocking return flow from the reservoir to said grease outlet,

(h) respective outlet means from the reservoirs to said further injection line,

(i) at least one further grease injection line to said passage at a location thereof below said high-pressure injection line,

(j) means for applying fluid pressure selectively to individual reservoirs of said plurality of reservoirs for returning grease accumulated in the selected reservoir through said further injection line to the wireline passage while permitting simultaneous flow of grease into said passage through said high-pressure injection line and flow of grease from said grease outlet to at least one other of said reservoirs.

15. A sub-sea well installation comprising

(a) a well head,

(b) a lubricator assembly mounted sealingly upon said well head,

(c) upper and lower parts in said assembly and releasable coupling means between said parts

(d) a grease control head mounted sealingly upon said assembly upper part,

(e) a through passage for the wireline extending continuously through the grease control head and the lubricator assembly to the well head,

(f) at least one wireline valve in the lubricator assembly, said valve having an inlet for grease injection into the wireline passage,

(g) wiper control means on the grease control head adjacent an upper end of said head,

(h) grease outlet means in said control head below and adjacent said wiper control means and connected to a grease outlet line,

(i) a plurality of reservoirs and respective conduit means connecting said grease outlet line of the control head to said reservoirs,

(j) non-return valve means provided in said conduit means to each said reservoir for blocking flow therethrough from the respective reservoirs to said grease outlet means of the control head,

(k) each said reservoir comprising a grease holding section and a fluid pressure injection section,

(l) a fluid-tight seal separating said sections and being displaceably mounted between said sections,

(m) means for applying fluid pressure to said injection section whereby to displace said sealing means to urge grease from the reservoir,

(n) return conduit means from each reservoir to said wireline passage,

(o) non-return valve means provided in the return conduit means from each said reservoir for permitting flow therethrough only in the direction from the reservoir to the wireline passage,

(p) means for applying said fluid pressure selectively to a respective one of said plurality of reservoirs for returning grease from said one selected reservoir to

said injection inlet while permitting the flow of grease from said outlet to at least one further said reservoir,

whereby alternate application of said fluid pressure in turn to each said reservoir while withholding said fluid pressure from another of said reservoirs permits a flow of grease from said outlet to alternate one of said reservoirs to be maintained while grease is being discharged from the other of said reservoirs to the wireline passage.

16. Apparatus for sealing around a flexible wireline, constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.

17. A sub-sea well installation constructed and arranged for use and operation substantially as described herein with reference to the accompanying drawings.

Published 1991 at The Patent Office, State House, 66/71 High Holborn, London WC1R 4TP. Further copies may be obtained from The Patent Office. Sales Branch, St Mary Cray, Orpington, Kent BR5 3RD. Printed by Multiplex techniques ltd, St Mary Cray, Kent, Con. 1/87